Revisiting phosphorus removal: do the models give the answers we want?

Amerlinck, Y.[1], Guisasola, A.[2], Ikumi, D.[3], Weemaes, M.[4], Brouckaert, C.[5], Hauduc, H.[6], Insel, G.[7], Baeza, J.A.[2], Comeau, Y.[8], Batstone, D.[9], Ekama, G.[3]

[1] BIOMATH, Department of Mathematical Modelling, Statistics and Bioinformatics, Ghent University, Coupure Links 653, 9000 Gent, Belgium
[2] Departament d'Enginyeria Química, Escola d'Enginyeria. Universitat Autònoma de Barcelona, Cerdanyola del Vallès, 08193,Cataloina,Spain
[3] Water Research Group, Department of Civil Engineering, University of Cape Town, South Africa
[4] Aquafin NV, Dijkstr 8, B-2630 Aartselaar, Belgium
[5] Pollution Research Group, School of Engineering, University of KwaZulu-Natal, Durban, 4041, South Africa
[6] Université de Toulouse; INSA, UPS, INP; LISBP 135 Avenue de Rangueil, F-31077 Toulouse, France
[7] Faculty of Civil Engineering, Environmental Engineering Department, Istanbul Technical University, 34469 Maslak, Istanbul, Turkey
[8] Polytechnique Montréal, C.P. 6079, Succ. Centre-ville, Montreal, Quebec, Canada H3C 3A7
[9] AWMC, Advanced Water Management Centre, The University of Queensland, St. Lucia, Queensland 4072, Australia

Introduction

Whole plant modelling gets increasing attention (Grau et al. 2007) and deals with linking the different models available for activated sludge, anaerobic digestion and anoxic-aerobic digestion. Due to the complexities in modelling P removal, the whole plant models also will have to deal with the effect of combining the biological and chemical models and their effect on each other (Barat et al. 2008, de Haas et al. 2000, Schonborn et al. 2001). Describing and predicting phosphorus (P) removal means looking at both biological and chemical processes. Modelling these processes has evolved over the years and result in a different status.

Modelling of biological phosphorus removal and in particular enhanced biological phosphorus removal (EBPR) has gotten a lot of attention during the 1990s resulting in the publication of the ASM2d (Henze et al. 1999). In the same period metabolic models (Lopez-Vazquez et al. 2009, Schuler and Jenkins 2003, Smolders et al. 1995) also have shown to be promising for modelling the EBPR. More recently, a lot of criticism arose about ASM2d concerning the inability to account for several processes and many extensions have been published (García-Usach et al. 2010, Larrea et al. 2002, Makinia et al. 2006, Manga et al. 2001).

Driven by problems of struvite precipitation, phosphate recovery and the need to predict pH, modelling chemical P removal has been getting a lot of attention in recent years, which led to the start of an IWA task group on a Generalized Physicochemical Framework (Batstone et al. 2012).

Today, it is clear that for modelling phosphorus removal at wastewater treatment plants a whole plant context is required that includes both biological and chemical processes. There is a lot of models and extensions of models available. The choice of model leads to a large uncertainty in the model outcome and reduces the confidence in their predictions.

WWTmod2014 is the fourth international seminar on wastewater treatment (WWT) modelling, after successful events in 2008, 2010 and 2012, and will be organized from March 30th till April 2nd in Spa (Belgium). WWTmod provides a platform upon which any relevant aspect of WWT modelling may be scrutinized. The main objective of WWTmod is consensus building. The process of consensus building is supported by obtaining insights from a diverse group of leading professionals: researchers, consultants, utilities, regulators, manufacturers, and software developers.

The poster will report on the highlights of the WWTmod2014 workshop "Revisiting phosphorus removal: do the models give the answers we want?"

Materials and methods

The workshop will attempt to find an answer to the following two questions. What are the prerequisites of the models to deal with practical questions (with respect to design and operation of wastewater treatment plants)? Is there a need for a consensus model to make the modelling of phosphorus removal a mature methodology? The first question will deal with several subtopics:

- What unit processes (AD, primary sedimentation, secondary sedimentation,…) are insufficiently modelled to describe the fate of phosphorus in a plant wide modelling context?
- What different populations do we need to consider in the model without including unnecessary details and complexity?
- What are the missing links/components to truly model physical-chemical processes?
- What is the impact of EBPR on other biological processes and vice versa?
- Are the currently known models sufficient?

Conclusions

Modelling phosphorus removal is an important factor for achieving the objectives of the activated sludge process (amongst others reducing eutrophication and resource recovery), set forth in the past and the future. The workshop "Revisiting phosphorus removal: do the models give the answers we want?" intends to set the path of future developments of modelling phosphorus removal.

References

Barat, R., Montoya, T., Borrás, L., Ferrer, J. and Seco, A. (2008) Interactions between calcium precipitation and the polyphosphate-accumulating bacteria metabolism. Water Research 42(13), 3415-3424.

Batstone, D.J., Amerlinck, Y., Ekama, G., Goel, R., Grau, P., Johnson, B., Kaya, I., Steyer, J.P., Tait, S., Takacs, I., Vanrolleghem, P.A., Brouckaert, C.J. and Volcke, E. (2012) Towards a generalized physicochemical framework. Water Science and Technology 66(6), 1147-1161.

de Haas, D.W., Wentzel, M.C. and Ekama, G.A. (2000) The use of simultaneous chemical precipitation in modified activated sludge systems exhibiting biological excess phosphate removal Part 1: Literature review. Water Sa 26(4), 439-452.

García-Usach, F., Ribes, J., Ferrer, J. and Seco, A. (2010) Calibration of denitrifying activity of polyphosphate accumulating organisms in an extended ASM2d model. Water Research 44(18), 5284-5297.

Grau, P., de Gracia, M., Vanrolleghem, P.A. and Ayesa, E. (2007) A new plant-wide modelling methodology for WWTPs. Water Research 41(19), 4357-4372.

Henze, M., Gujer, W., Mino, T., Matsuo, T., Wentzel, M.C., Marais, G.V.R. and Van Loosdrecht, M.C.M. (1999) Activated Sludge Model No.2d, ASM2d. Water Science and Technology 39(1), 165-182.

Larrea, L., Irizar, I. and Hidalgo, M.E. (2002) Improving the predictions of ASM2d through modelling in practice. Water Science and Technology 45(6), 199-208.

Lopez-Vazquez, C.M., Oehmen, A., Hooijmans, C.M., Brdjanovic, D., Gijzen, H.J., Yuan, Z.G. and van Loosdrecht, M.C.M. (2009) Modeling the PAO-GAO competition: Effects of carbon source, pH and temperature. Water Research 43(2), 450-462.

Makinia, J., Rosenwinkel, K.H., Swinarski, M. and Dobiegala, E. (2006) Experimental and model-based evaluation of the role of denitrifying polyphosphate accumulating organisms at two large scale WWTPs in northern Poland. Water Science and Technology 54(8), 73-81.

Manga, J., Ferrer, J., Garcia-Usach, F. and Seco, A. (2001) A modification to the Activated Sludge Model No. 2 based on the competition between phosphorus-accumulating organisms and glycogen-accumulating organisms. Water Science and Technology 43(11), 161-171.

Schonborn, C., Bauer, H.D. and Roske, I. (2001) Stability of enhanced biological phosphorus removal and composition of polyphosphate granules. Water Research 35(13), 3190-3196.

Schuler, A.J. and Jenkins, D. (2003) Enhanced biological phosphorus removal from wastewater by biomass with different phosphorus contents, part I: Experimental results and comparison with metabolic models. Water Environment Research 75(6), 485-498.

Smolders, G.J.F., Vandermeij, J., Vanloosdrecht, M.C.M. and Heijnen, J.J. (1995) A structured metabolic model for anaerobic and aerobic stoichiometry and kinetics of the biological phosphorus removal process. Biotechnology and Bioengineering 47(3), 277-287.